ENERGY SAVING IN RELIGIOUS BUILDINGS

Ontario Ministry of Energy

Honourable Robert Welch, Q.C.
Minister

Message from the Minister

Rising energy costs have been with us for a number of years now, and they aren't likely to go away. These increases hit religious organizations especially hard because much of the money used to pay those high energy charges comes from the congregation.

There are many useful projects that your group could be implementing with that money — and that's one of the many reasons for concern over high energy bills.

Energy conservation can help to ease the financial strain on your congregation. Some measures — such as caulking, adding weatherstripping, and reducing heat and lights in unoccupied areas — are obvious. Others, such as installing insulation and double glazing require deeper investigation and some initial capital investment.

But whether your congregation is just beginning to explore energy conservation or has already instituted a program, this booklet can help by providing an organized approach to energy conservation. If you're new to conservation, it can help lay the groundwork for a comprehensive program; if you've established a program, the methods and checklists may provide new ideas that will lead to further savings.

The Ontario Ministry of Energy would like to help you start an energy conservation program. We hope you will find some useful tips in this booklet. If you need further assistance, please get in touch with us.

Good luck in your energy management program,

Sincerely,

Robert Welch

The Honourable Robert Welch
Minister of Energy

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from the
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Toll free long distance
1-800-268-7540;
In Northwestern Ontario
0-Zenith 67200.

ISBN 0-7743-7548-5
Printed July 1982

This publication was adapted from a Ministry of Energy publication called — "Energy Conservation in Public Buildings" (First Printing May 1978)

Introduction

Central to any energy-saving program are five vital steps:

1. Set up an energy management team.
2. Survey your building.
3. Decide on measures.
4. Make a detailed plan.
5. Implement the program.

This booklet can help your energy management program by providing a number of tools that can be used within this general framework:

- Background information on the Ontario energy situation and on conservation policy-making that can help motivate each member of the energy management team.
- Descriptions of some of the general principles behind conservation: architectural considerations; general conservation methods; and heating, ventilation, lighting and mechanical loads.
- Checklists dealing with specific energy saving measures.
- A discussion of the all-important issue of energy forms — how to decide which forms are best for your facility.
- Tables dealing with degree days, metric conversion, and the conversion of various energy units to British Thermal Units (Btu's) and equivalent kilowatt-hours (EkWh).
- Forms to help you tabulate energy consumption and savings.

The booklet has been prepared for those concerned with the administration, planning, financing, operation and maintenance of religious buildings including: houses of worship; sanctuaries; manses, presbyteries and rectories, and hostels.

It deals with the conservation measures that can be undertaken in existing buildings. Please note, however, that substantial savings can be made in new buildings through the application of proper codes and standards, and up-to-date building practices.

The Ontario Situation

Energy requirements and accepted standards of comfort vary from country to country. Here in Canada, our energy requirements are high, largely because of heating needed during our long, cold winters. In Canada, our standards of comfort are also quite high compared to those of other countries.

Energy conservation enables us to lower our energy requirements and at the same time maintain comfort in our buildings. Some measures — added insulation for example — serve to increase the comfort levels as well as reducing fuel costs.

There are other reasons for Canadians, and Ontarians in particular, to be concerned about saving energy. Ontario produces only about 25% of its energy requirements from indigenous resources. In addition, the continued availability of some forms, particularly oil, is uncertain. We should, therefore, try to reduce our dependence on non-indigenous forms of energy by using more abundant indigenous forms of conventional energy and renewable energy wherever it is economic.

For the foreseeable future, we have enough indigenous forms of conventional energy such as natural gas and electricity. And developments in renewable energy in such areas as solar, now makes these facilities worth considering for conditioning some types of buildings.

Conservation Policy — What's Involved

Developing, refining and correctly applying energy-saving methods and devices are the domain of the engineer and scientist. Once these methods are made available, the choice of which ones to use is a matter of policy. Many perfected methods or devices conserve energy but involve additional first costs or extra skill and effort in the operation of the building.

Deciding which method to use involves weighing various considerations. For a religious organization concerned with the operation of buildings, it is a matter of striking the best balance between the short-term and long-term spending of congregational funds. This involves a critical re-examination of current policies and attitudes towards:

- criteria for capital cost of buildings;
- criteria for quality, involving the cost of operating and maintenance personnel;
- criteria for ventilation rates, lighting levels, personal comfort and convenience.

For large capital projects, a process called 'life-cycle costing' can be used to select the least expensive items of equipment overall. This process takes into consideration both purchase and total lifetime operating costs. For more information contact: The Advisor, Energy Conservation in Religious Buildings, Ontario Ministry of Energy, 56 Wellesley St. W., Toronto, Ontario M7A 2B7, telephone (416) 965-3053.

Architectural Considerations

Those concerned with the planning, administration, financing, and operation of religious buildings should insist that energy conservation be an important feature of the design criteria for any renovations.

Design decisions determine the shape of a building, the materials used in its construction, and the basic energy-use patterns involved in its operation, as well as the additional materials required to maintain or renovate it. A building cannot make optimum use of its energy resources unless it is designed to take advantage of natural elements. A basic design principle should be to complement, not ignore, the natural environment.

Shape
The building's shape will partly determine the energy required to heat and cool the building, since heat gains and losses are transmitted through the walls and roof. One of the ways in which the designer can limit energy use is to minimize the surface area.

Passive Solar Energy
One way to save "purchased" energy is to make use of passive solar energy. Unlike active solar energy, which uses a variety of mechanical components to make use of the sun's energy, passive solar energy sytems use building design and arrangements of components to collect, store and transfer heat.

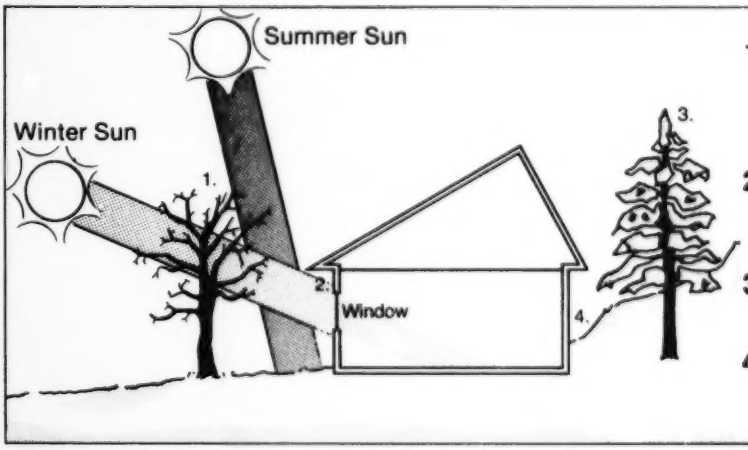
Passive space conditioning techniques are perhaps the most cost-effective way to realize the potential of solar energy.

Windows
The location and size of windows are important. Double-glazed, south-facing windows are most useful for solar heating. When planning renovations, the amount of glass on the north side should be minimized, as it receives no usable direct solar energy during the winter.

Windows allow the sun to shine in, but they are also a major source of heat loss when the sun does not shine. Double-paned windows can cut outward heat losses by up to 50%, while reducing the amount of sunlight that enters the building by day by only about 10%. Heavy curtains, blinds or shutters can decrease the heat losses from windows at night.

During the summer, when cooling is desired, vents and open windows, properly located, let in summer breezes for natural ventilation. Because of the tendency of warm air to rise, cooler air enters at ground level, while warmer air is exhausted at the top.

Figure 1 - Passive Solar and Landscaping Features take advantage of seasonal changes in the sun's position and foliage.



1. Deciduous trees planted on the south side of the building provide shade in summer, but allow the sun's rays to penetrate during winter.
2. Overhang excludes summer sun, but allows beneficial winter sun to intrude.
3. Evergreens planted on the north side help minimize wind exposure.
4. Earth banked on the north side of the building further reduces its exposure.

Conservation Methods

Landscaping and Other Passive Solar Measures
The use of deciduous trees can provide shade during the summer, while bare branches will allow the sun to pass through in the winter.

Evergreens planted on the north side of the building help minimize wind exposure. Earth banked on the north side of the building can further reduce its exposure.

Light exterior colours reflect the sun's rays. This is especially important for summer cooling.

Overhangs can be used to minimize summer sun, but allow beneficial winter sun to enter the building (see Figure 1).

The following recommendations cover most energy conservation methods and strategies.

1. Manage plant so that it consumes energy only when needed and in amounts needed.
2. Eliminate waste of energy due to inadequate maintenance.
3. Reduce energy loads to a minimum, taking occupancy requirements and economic factors into account.
4. Use equipment and systems that utilize energy efficiently.
5. Utilize the more abundant forms of energy to reduce the use of more expensive or uncertain forms such as oil.

Operation and maintenance procedures will apply more to existing facilities. The choice of systems, load levels, and forms of energy will apply more to new construction, although they could apply to an existing building if retrofitting, readjustment, and replacement of systems are considered.

Operation
Operating procedures should be reviewed carefully so that opportunities for saving may be identified. This will involve devising an efficient timing system for the operation of the lighting, ventilation, and heating systems. Timing procedures for the "night cycle" and the "shut-down cycle" should be particularly precise and rigidly applied. The night cycle should incorporate a set-back of temperature to 13°C (55°F) during the heating season, the closing of all outside air dampers, and the shut-down of all exhaust fans.

Such timing cycles require the installation of automatic time clocks. In large religious buildings, a central monitoring and control console should be considered. More sophisticated centralized-control equipment allows the use of different cycles for various areas and facilities of the building, and also allows relatively easy changes and adjustments to the timing cycles. Over-ride timers permit manual re-set of the "day cycle" for after-hours occupancy, and return the control to the main time clock after a fixed number of hours.

In small buildings, the automatic timing of the heating, ventilation, and lighting systems may not be feasible or economical; maintenance and operating personnel should carry out such schedules manually.

The tightening of operating procedures is one of the simplest energy conservation measures; at the same time, it is one of the most effective and rewarding. (Energy savings of 10% to 25% or more have been achieved.)

Further details relating to operating procedures and scheduling are given in the 'Operation Checklist' section.

Maintenance

Inadequate maintenance, carried out in a sporadic, unorganized manner, results in excessive energy consumption. Proper maintenance saves both energy and equipment. A specific person with appropriate qualifications should be made responsible for reviewing maintenance and operating procedures as they relate to energy conservation. Definite goals should be set: for example, a reduction in energy consumption of 20%.

The energy conservation committee should institute a survey of the energy consumption of the building(s) in its jurisdiction. A questionnaire should be prepared, asking for statistics on the monthly consumption of various forms of energy, as well as for data regarding size of facilities, population, use, and the type of heating and ventilation plant. Every such survey seems to yield a number of surprises. When the annual energy consumption of a group of very similar school buildings — all constructed in the same year in Toronto — was compared, it was found that some of them were consuming more than twice as much energy as others. A thorough check of the "problem" schools revealed maladjustment of controls, jammed outside-air dampers, and other maintenance problems. Similar situations may prevail among religious buildings.

Programs designed to upgrade maintenance measures and personnel should be instituted. Educational programs for congregational personnel should draw attention to the energy situation and outline the methods and procedures that may be employed to bring about energy savings.

Preventative maintenance will save energy. Particular attention should be given to systems that are most likely to cause excessive energy consumption through maladjustments or lack of maintenance. These include ventilation systems, boilers and their combustion systems, and automatic temperature-control systems.

For service of the more complicated equipment, contracts should be arranged with qualified outside firms. Maintenance personnel should have adequate maintenance manuals on equipment that they operate and maintain.

Further details regarding suggested maintenance procedures are given in the *Maintenance Checklist* section.

Heating, Ventilation, Lighting and Hot Water

The heating, ventilation and lighting loads of buildings should be reduced to the minimum levels that satisfy occupancy requirements. Every component of these loads should be carefully considered and its effect on energy consumption assessed.

Insulation
Rising energy costs more than justify installing high values of insulation in all new buildings. In existing buildings, increasing the insulation should be studied to see if it is economically viable. In estimating the economic benefits of insulation, one should include the savings in fuel, the decrease in the power consumption of circulating fans and pumps, and the reduced capital costs of the mechanical plant. The energy consumed by circulating fans can be quite substantial in forced-air heating systems.

The American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE) 1980 Guide (see 'For More Information' section) can provide more details on insulation standards.

The cost of providing insulation beyond the point of optimum economy is relatively small. Indeed, in providing extra insulation at such low cost, it would be prudent to go beyond optimum economy in order to conserve more energy and to provide a buffer against future energy-cost increases. Figure 2 illustrates the economics of insulation.

With roof assemblies that require fire protection ratings, the maximum allowable thickness of insulation must be established. The allowable insulation thickness for different types of roof design should be investigated by contacting the Ontario Office of the Fire Marshal and the insurance underwriters.

Infiltration
Infiltration of outside air represents a substantial portion of the total heating load of a building, often 30 to 50%. The infiltration properties of the building fabric generally do not receive as much scrutiny and attention as the heat transmission or insulation properties.

One reason for this is that the infiltration data for various building materials cannot be as accurate as the heat conduction data.

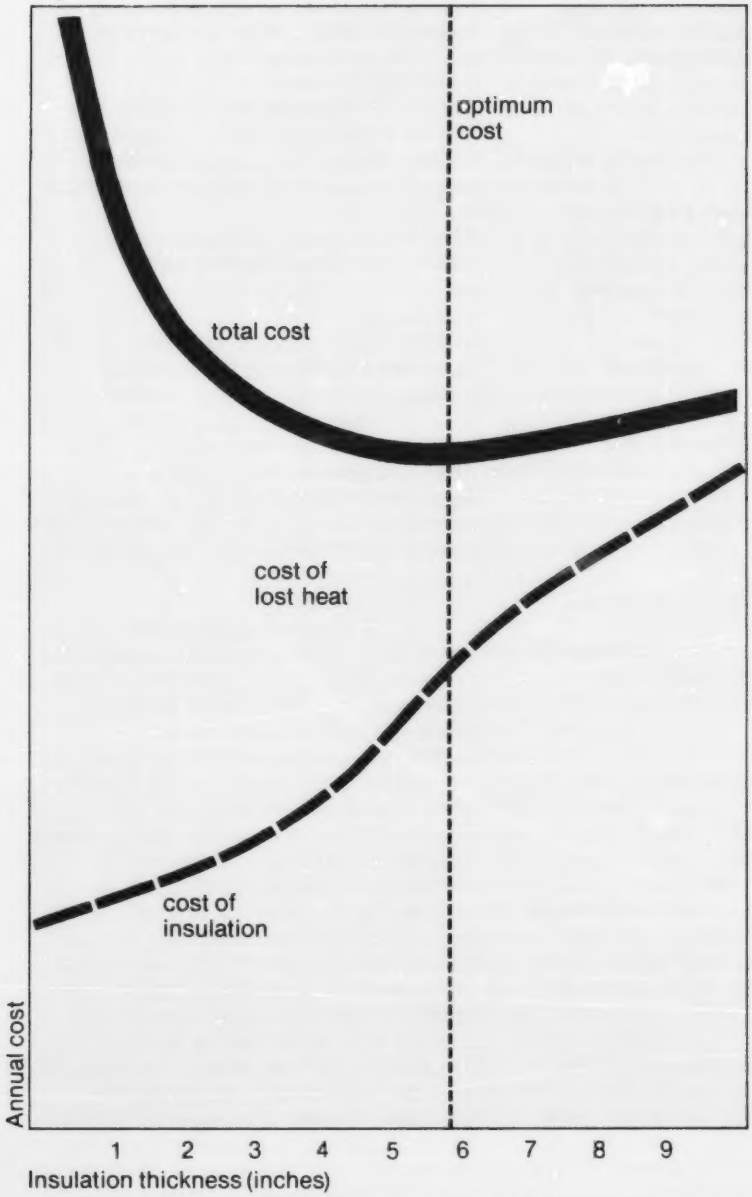
For the energy-oriented designer, the choice of building fabric components should depend as much on infiltration properties as on conduction properties.

Weather stripping and caulking can reduce infiltration substantially.

Ventilation
Mechanically-induced ventilation is normally used during the hours of occupancy. At such times ventilation may represent the largest single component of the total heating load; therefore, considerable care must be exercised in selecting the amount of outside air to be used, the design of the ventilation system, and the arrangement of its controls.

A National Building Code committee is in the process of producing a Canadian Code for Energy Conservation in New Buildings, and the Ontario Building Code is to be revised shortly. These codes may govern ventilation rates, and will probably be based on the ASHRAE 90A, 1980 Code. Pending the introduction of the new codes, the minimum ventilation rates recommended by ASHRAE should be applied. Since it is neither the depletion of oxygen nor the build-up of carbon dioxide but the dilution of objectionable body odours that governs ventilation requirements, the recommended rates are approximate and are stated with some latitude. The required amount of ventilation depends on room volume per occupant; the prevailing dietary and hygienic habits of the occupants; the type of activity conducted; and the amount of air being recirculated if such air passes through water sprays and filters. When using these recommendations, one should clearly understand what is meant by the suggested ventilation rates. They do not always refer to the amount of air indicated by the damper setting in the central ventilation unit; nor do they necessarily refer to the amount of air that has to enter the room through the

Figure 2 — Insulation Economics



The lowest combination of installed-insulation costs and heat-loss cost determines the thickness of insulation that is practical from the point of view of cost.

mechanical ventilation system. What they indicate is the amount of odour-free, non-contaminated air that needs to be provided.

Natural infiltration can provide a substantial amount of ventilation in cold weather. This is borne out by actual experience in many buildings. Automatic controls in some buildings are arranged to close all fresh-air intakes at -1°C (+30°F)* or lower outside air temperatures. For each building, this possibility should be studied.

In buildings with central ventilation systems, fresh air should be provided on the basis of the number of occupants. One should not make the error of assuming that the same people can be everywhere at the same time. In addition, a central recirculating ventilation system increases the effective volume of air per occupant as it recirculates and mixes air from unoccupied spaces.

Air should not be recirculated from certain areas, such as washrooms, change rooms, locker rooms and kitchens. Separate fresh-air supply systems for such areas should be avoided; where possible, make-up air should be taken from other areas of the building or from the central ventilation system. Rather than being ejected directly into the atmosphere from office areas, the air should be allowed to pass to areas that need to be exhausted without recirculation. In this way the outside air required for the ventilation of offices will do double duty. Also, by means of such transferring of air, the total amount of outside air required for the building can be reduced. The designer, however, will need to check that negative pressures are not established that might cause air to flow from washrooms, etc. to offices.

Ventilation systems should be designed in such a way that it should not be necessary to ventilate the whole building when only part of the building is in use. It may be desirable to provide a separate ventilation unit for an

* Standard taken from ASHRAE Transactions Research Reports.

auditorium or other similar space that may be used by the community after regular hours. A zoned system should be considered.

Lighting
Much of the electrical energy consumed in our buildings can be traced to lighting. Lighting should be reassessed with a view to conserving energy.

Lighting design should stress quality rather than quantity. With careful design and the use of efficient luminaires, the necessary lighting levels can be achieved with less power. Over-lighting should be avoided, particularly in auxiliary areas such as lobbies, corridors, storage rooms, and similar spaces. Lighting in such areas should be reduced to the lowest levels that safety and security will allow. It is frequently possible to reduce lighting consumption by 15 to 65%, just by changing to different types of lamps or tubes. One easy and effective measure is installation of elliptical reflector lamps. More information on energy efficient lamps, tubes and luminaires can be found in the 'Lighting Section' later in this booklet.

Choose colours that reflect light. Keep walls and ceilings clean. Dark colours and dirt reduce illumination by as much as 40%.

Consider installing a number of separate lighting circuits or modern solid-state dimmers in areas where high levels of lighting are needed only periodically.

One of the best economy measures is to turn off the lights when a room is not in use.

Hot Water
In religious buildings, considerable amounts of hot water and therefore energy, can be used unnecessarily in wash basins. Conservation faucet aerators are available that reduce the rate of flow significantly without reducing its effectiveness for hand-washing purposes. Furthermore, the reduction in flow rate is not readily detectable. The conservation faucet aerators are available in various sizes and can be fitted in a few minutes. They are inexpensive and can pay for themselves, in terms of energy and water saved, in several months.

The type of mechanical system selected, its size, and the type of equipment it uses affect the energy consumption of a building. Mechanical systems should have a high energy-utilization efficiency. The inclusion of waste-heat recovery devices should be carefully considered. Systems with high transportation energy requirements should be avoided.

Efficiency
Fans and pumps should be chosen for maximum efficiency. The more efficient equipment usually requires less horsepower for operation, and thus can result in a sizable saving in energy, as much of this equipment operates 24 hours a day. The use of high efficiency electric motors can further increase these savings. Systems chosen for maximum efficiency may at times involve larger and more expensive components.

Air ducts and water pipes should be sized to reduce the friction losses of a system. This may involve increased building space requirements. Air filters should be chosen for their ability to reduce friction losses and yet maintain high filtration efficiency.

Temperature control zones should be sized to avoid over-heating. Each area of the building that has distinct heating requirements — due to varying population loads, solar gains, lighting loads, or other heat-producing equipment loads — should have its own thermostatic control.

The efficiency of a system will also depend on the functioning of automatic controls. Automatic control systems should be simple, reliable, and easy to operate.

The choice of energy forms for buildings has traditionally been limited to electricity and fossil fuels. Electricity is used for lighting and for powering fans, pumps etc. For heating, either electricity or a fossil fuel such as gas, oil or coal is used.

Other technologies involve using solar energy directly from the sun, or indirectly in the form of wind or biomass, and energy derived from wastes. Such technologies are currently in the development and demonstration stages, but may one day play an important role in Ontario's energy future.

The prices of all forms of energy are expected to rise, but the price of oil is expected to rise faster than that of natural gas or electricity. In addition, conventional sources of oil are being depleted. If your religious building uses oil for heating, serious consideration should be given to converting to natural gas or electricity.

The following considerations will figure in any decision to convert:

1. The availability of natural gas in your area.
2. The condition of your oil furnace. If it needs to be replaced, the time may be ripe to switch away from oil. Grants are available under the Canadian Oil Substitution Program (COSP) to help cover the cost of conversion away from oil.

The decision depends to a large extent on your specific situation. If you're considering conversion away from oil, contact your local natural gas office, propane distributor or electrical utility for advice.

Recommendations

In existing buildings, the more practical energy-conservation measures consist mainly of upgrading the operation and maintenance procedures. This should include a review of the original design criteria for the mechanical and the electrical systems. One should look carefully at the possibility of reducing the ventilation rates, lighting levels, space temperatures, and humidity levels. It is generally possible to reduce the minimum fresh-air settings of unit ventilator systems and the central ventilation systems. Lamps can be reduced in size or removed from lighting fixtures in non-essential areas such as corridors, storage rooms, basements, etc. In some cases, lamps can also be reduced in size or removed in working areas such as offices or meeting rooms. More care is required in such locations, however, as non-uniform lighting will result with some fixture layouts.

Care must be exercised in delamping by removal of fluorescent tubes. Generally these tubes are paired on an electrical ballast. Thus, two tubes operating on the same ballast can be removed from a four-tube fitting, but the unused ballast should be disconnected. One tube should not be removed from a pair unless it is replaced with a dummy tube. A competent electrical technician should supervise delamping.

Modernization or retrofitting of existing buildings should be considered with a view to effecting savings in energy consumption. It is unlikely, however, that extensive retrofitting will prove economically justifiable. The first cost of alterations is usually higher than that of new construction. Also, the remaining (and often relatively short) life of an existing building may not warrant spending large sums on upgrading. Opportunities for modernization will arise from the need to replace worn-out boilers, burners, and other equipment.

The economic validity of expensive improvements, such as adding insulation to existing walls and roofs, and installing waste-heat recovery equipment, should be investigated thoroughly before proceeding.

On the other hand, some low-cost improvements may be economical, such as insulating bare heating pipes and steam pipes, adding time clocks for lighting and ventilation systems, adding a night set-back feature to temperature controls, and rewiring office lighting to allow switching off of fixtures adjacent to windows. Other inexpensive but effective measures include weather stripping and caulking around doors and windows.

Supplementary Information — Operations Checklist

1. Ensure that operating personnel are familiar with equipment, installations, and distribution systems.
2. Make available pertinent drawings and operating instructions to conservation personnel.
3. Develop schedules and instruct cleaners, guards and other personnel to turn the lights off at predetermined times.
4. Schedule control and switching off of street area, perimeter, and floodlighting.
5. Investigate the possibility of rescheduling operations in order to decrease the peak loads on utilities.
6. Develop a building heating schedule to allow the most economical use (i.e., the most advantageous turning "on" and "off" points) of steam, hot water, and electrical heating.
7. Ensure boilers are operating at maximum efficiency. Some useful tips on optimizing the efficiency of fire-tube boilers are listed in the 'Fire Tube Boiler' section near the end of this booklet.
8. Shut down motor-operated equipment whenever possible to reduce power consumption.
9. Lower storage tank temperatures of domestic hot water heating systems to the point where the storage capacity is just sufficient to meet the occupancy requirements.
10. Check calibration of controls for air-conditioning systems and boilers to ensure the most efficient performance.
11. Set back thermostat controls to 13°C (55°F) for shut-down periods.
12. Place lamps to give the desired illumination at task stations and reduce lighting levels in non-essential areas.
13. Check that all plumbing fixtures are turned off when not in actual use.
14. Keep accurate records, properly tabulated and supplemented with graphs. They should include:
    - consumption of fuels, water and electricity;
    - production of steam where steam is being generated;
    - changes in operating procedures (e.g., changes in scheduling equipment shutdown, adjustments, etc.);
    - inspections;
    - modifications and improvements pertaining to energy savings and related installation costs.

    The records should show changes in energy consumption resulting from the implementation of the energy-conservation program. An evaluation of savings should be based on the annual meteorological records. A summary of fuel and electricity consumption for each year should be prepared.
15. Have the appropriate utility monitor flue gases on an annual basis to ensure optimum combustion.
16. Develop specifications for new equipment to ensure that it is designed to use the minimum amount of energy within the requirements of performance, longevity, and maintenance.
17. Do not buy inexpensive and inferior equipment to save money on initial cost. More often than not, inferior equipment consumes more fuel or electricity.
18. Consider installing monitoring devices on equipment that uses large amounts of energy. The monitoring device should sound an alarm or shut down improperly maintained equipment until malfunctions are corrected.
19. Institute an educational program for conservation staff relating to the conservation of energy. The program will need repeating as new techniques become available and also to train new personnel.
20. Thoroughly investigate the use of destratification fans.
21. Consider changing to alternate forms of energy to save energy and money.

Maintenance Checklist

1. Establish a controlled preventive maintenance program.
2. Clean lighting fixtures and replace unserviceable light bulbs and fluorescent tubes regularly.
3. Check air filters of ventilation and air-conditioning systems on a regular schedule.
4. Maintain equipment to ensure operation at optimum efficiency.
5. Clean all equipment regularly.
6. Enter into maintenance contracts for specialized systems such as controls, refrigeration equipment, water treatment, etc.
7. Conduct combustion efficiency tests at regular intervals and make any necessary adjustments.
8. Weather-strip windows and door openings, caulk window and door frames. Storm door and window installation should be considered.
9. Provide insulation, where economically feasible, for roofs, walls, ceilings, and floors.
10. Seal all sky-lights and other roof openings as tightly as possible to reduce the "chimney-effect".
11. Improve insulation of steam mains, risers, runouts, etc. Add insulation to all uninsulated pipe fittings, flanges, and equipment.
12. Check radiation surfaces for obstructions such as blank covers.
13. Remove or shut off unused steam and return piping of steam distribution systems.
14. Check hydronic systems for the proper temperature difference between supply mains and return mains.
15. Examine air distribution ducts for leaks, deterioration, separation of insulation, heat pick-up from pipes, and required insulation improvements.
16. When replacing electrical fixtures, use more efficient fixtures wherever possible, taking into consideration the efficiency of lamp sources and fixture design.
17. When alterations are being made, evaluate the light reflectances of walls, floors, and ceilings to achieve more efficient light utilization.
18. Add automatic controls wherever possible to allow the most economical operation of equipment.
19. Install clocks, photo-cells, and other controls to ensure the predetermined cycle of operation.
20. Revise electrical circuits to allow partial switching of electrical loads.
21. Add zone controls, day-night controls, mixing temperature controls, return controls, return-air temperature controls, etc., as required, to reduce energy consumption.
22. Consider having a competent combustion engineer make a flue gas analysis at least once a year to properly adjust the fuel input and to optimize combustion.
23. Check all steam traps for size, type and leaks. Have leaking steam traps replaced promptly as these are a major source of energy wastage.
24. Check on effective operation of destratification fans.

Degree Days Table

The number of degree days is quite important in establishing an energy consumption analysis form. A degree day is a standard measure used by heating engineers to measure the heating season's coldness. The number of degree days in a calendar day is determined by subtracting the day's average temperature from 18°C (65°F). If the high on a given day was 15°C (59°F) and the low was 5°C (41°F), the average temperature that day would be 10°C (50°F).

Subtracted from 18°C (65°F), this would give 8°C degree days or 15°F degree days for the calendar day. No degree days are counted when the mean temperature is above 18°C (65°F).

For a logical comparison, each heating period's operation should be corrected to the normal degree days for the appropriate area and year.

In order to compare total energy consumption for the current year with the base year, you will need to obtain the number of degree days for both years. Degree days information can be obtained from the nearest meteorological office.

The table below[1] gives the average monthly and yearly degree days for some Ontario towns and cities.

Degree Days Celsius[2] Below 18°C

Location	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly Total
Belleville	794	692	590	342	175	39	6	15	96	253	439	700	4141
Chalk River	909	779	644	378	194	59	13	31	130	291	502	808	4738
Cochrane	1110	948	839	517	316	135	68	107	229	391	652	982	6294
Goderich	737	666	620	377	227	71	23	29	102	261	447	651	4210
Huntsville	876	766	668	394	220	74	28	46	138	297	505	784	4796
Kapuskasing	1123	956	841	521	319	136	70	105	232	401	667	995	6365
Kenora	1109	924	776	466	259	91	27	47	196	373	678	986	5930
Kingston	807	710	599	353	184	45	6	14	91	246	438	700	4192
Kirkland Lake	1086	930	813	495	288	115	65	94	218	397	619	964	6085
Kitchener	760	677	595	347	183	48	11	21	101	258	455	684	4139
London	746	668	582	342	183	48	12	22	98	251	446	670	4067
Moosonee	1183	1020	928	608	392	200	106	130	244	414	674	1032	6931
North Bay	956	823	725	444	248	87	37	62	176	343	564	853	5318
Orillia	834	730	660	390	217	63	18	28	120	276	479	741	4555
Ottawa	899	778	654	371	181	44	10	28	123	290	499	796	4674
Owen Sound	742	666	600	367	216	66	18	21	103	240	434	668	4141
Parry Sound	856	761	669	403	228	70	21	32	125	280	479	751	4674
Port Dover	703	633	557	341	177	44	9	16	82	236	417	627	3843
St. Catharines	650	594	517	312	157	33	5	7	65	192	385	595	3512
Sarnia	717	635	540	348	201	59	17	22	85	224	416	636	3899
Sioux Lookout	1136	955	811	500	295	109	39	68	216	397	695	1016	6236
Sudbury	982	860	752	452	255	87	33	59	176	348	572	871	5446
Thunder Bay	1017	877	749	469	301	131	47	71	204	371	616	893	5744
Toronto	694	615	539	313	158	32	4	7	70	212	395	614	3653
Windsor	691	606	520	295	141	29	3	8	64	204	411	618	3590

NOTE: 1. For more complete data, refer to "Degree Days Ontario 1941-1970" as issued by Fisheries and Environment Canada.
2. Celsius degree days x 1.8 = F degree days.

Energy Consumption Forms

The following forms have been developed to assist in monitoring and assessing building energy requirements and consumption.

UNIFORM ENERGY ACCOUNTING AND REPORTING FOR BUILDINGS: FUEL OIL

BASE YEAR____REPORTED BY_____ LOCATION _____

PRIMARY FUEL?_____STANDBY FUEL?_____

FACILITY SIZE, FT²_____M²_____ SHEET_____OF_____DATED_____

1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
YEAR 19____	READING DATES		FUEL USED LITRES X _____			$COST		$/LITRE		DEGREE DAYS		LITRES/DD		± % LITRES PER DD	EKWH/ M²/DD*		REMARKS
MONTH	FROM	TO	CURRENT	BASE	DIFFERENCE	CURRENT	BASE	CURRENT	BASE	CURRENT	BASE	CURRENT	BASE				
JAN																	
FEB																	
MAR																	
1ST Q.																	
APR																	
MAY																	
JUN																	
2ND Q.																	
JUL																	
AUG																	
SEP																	
3RD Q.																	
OCT																	
NOV																	
DEC																	
4TH Q.																	
TOTAL																	

*Equivalent kilowatt hours/metre²/degree day

UNIFORM ENERGY ACCOUNTING AND REPORTING FOR BUILDINGS: ELECTRICITY

LOCATION _____

BASE YEAR ____ REPORTED BY _____

FACILITY SIZE, FT² _____ M² _____

SHEET ____ OF ____ DATED _____

1	2		3		4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
YEAR 19____	READING DATES		TOTAL DAYS		KWH USED X _____			$ COST INCLUDING DEMAND CHARGES		$/KWH INCLUDING DEMAND CHARGES		KILOWATT DEMAND		COMPARISON			EKWH/ M²/DD*		REMARKS
MONTH	FROM	TO	CURRENT	BASE	CURRENT	BASE YEAR	DIFFERENCE	CURRENT	BASE YEAR	CURRENT	BASE YEAR	CURRENT	BASE	± % KWH	± % KW	- % $			
JAN																			
FEB																			
MAR																			
1ST Q.																			
APR																			
MAY																			
JUN																			
2ND Q.																			
JUL																			
AUG																			
SEP																			
3RD Q.																			
OCT																			
NOV																			
DEC																			
4TH Q.																			
TOTAL																			

*Equivalent kilowatt hours/metre²/degree day

UNIFORM ENERGY ACCOUNTING AND REPORTING FOR BUILDINGS: NATURAL GAS

LOCATION _____

BASE YEAR _____ REPORTED BY _____

FIRM? _____ INTERRUPTIBLE? _____ ALTERNATE FUEL _____

FACILITY SIZE, FT² M²

SHEET ___ OF ___ DATED _____

1	2		3		4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
YEAR 19___	READING DATES		TOTAL DAYS		FUEL USED LITRES X _____			$COST		$/LITRE		DEGREE DAYS		LITRES/DD		± % LITRES PER DD	EKWH/ M²/DD*			
MONTH	FROM	TO	CURRENT	BASE	CURRENT	BASE	DIFFERENCE	CURRENT	BASE	CURRENT	BASE	CURRENT	BASE	CURRENT	BASE					REMARKS
JAN																				
FEB																				
MAR																				
1ST Q.																				
APR																				
MAY																				
JUN																				
2ND Q.																				
JUL																				
AUG																				
SEP																				
3RD Q.																				
OCT																				
NOV																				
DEC																				
4TH Q.																				
TOTAL																				

*Equivalent kilowatt hours/metre²/degree day

Conversion Tables

Table 1 Conversion to B.T.U.s and Equivalent Kilowatt Hours

Energy Type	*Units*	*B.T.U.s*	*EkWh*
Light Fuel Oil	litre	36,593	10.72
Heavy Fuel Oil	litre	39,480	11.57
Natural Gas	cubic metre	35,300	10.34
Steam	kilogram	2,205	0.65
Steam (Condensate not returned)	kilogram	2,600	0.76
Chilled Water	tonne	13,225	3.9
Electricity	kWh	3,413	1.0

Table 2 Metric Conversion

British Units Multiply the number of	*by*	*SI Units to find the number of:*
gallons (Imp.)	4.546	litres (l)
gallons (U.S.)	3.785	litres (l)
cubic feet (ft^3)	0.02832	cubic metres (m^3)
square feet (ft^2)	0.09290	square metres (m^2)
°F degree days	0.5556	°C degree days
kWh/ft^2	10.76	kWh/m^2
B.T.U.s	1.055	kWh/m^2
$B.T.U.s/h/ft^2/°F$	20.44	$kj/h/m^2/°C$

Some forms of lighting, such as fluorescent and High Intensity Discharge (HID), are much more efficient than incandescent. Typically, such lamps provide at least three times more light per watt than incandescent, and last at least five times as long. The following are among the most useful energy-efficient lamps, tubes and luminaires available.

Fluorescent Lighting
Fluorescent lighting is suitable for most indoor areas. Energy consumption can be further reduced by using the following energy-efficient tubes in regular fluorescent fittings.

Power Consumption (Watts)

	REGULAR	ENERGY EFFICIENT
4 foot	40	35
8 foot - regular	75	60
8 foot - high OUTPUT	120	100

High Intensity Discharge (HID) Luminaires
The most common types of HID luminaires are: mercury vapour, and high and low pressure sodium.

Mercury vapour luminaires are suitable for indoor use in areas with high ceilings where the lights are required to be on for long periods of time.

Low pressure (LP) sodium and high pressure (HP) sodium lighting are suitable for outdoor uses such as for lighting building perimeters and car parks. HP sodium is peach coloured, while LP sodium lighting is amber coloured. Both are widely used for illuminating highways and shopping mall carparks. LP sodium is one of the most energy-efficient forms of lighting available.

Elliptical Reflector Lamps
Many religious buildings use 150 watt reflector lamps for both indoor and outdoor illumination. These lamps have a parabolic shaped reflector and are normally fitted in recessed, non-reflective luminaires. Unfortunately, because of the wide parabolic-shaped reflector, much of the light gets trapped inside the luminaire and the useful amount of light is greatly reduced. Elliptical reflector lamps overcome this problem by focusing the light to a point several inches outside the lamp. Since the light then spreads out from this point almost all the light is projected from the luminaire, resulting in much greater efficiency. Elliptical reflector lamps are available in the following sizes:

Size or Power Consumption	*Manufacturer's Description*
50 watt	50 ER 30
75 watt	75 ER 30
120 watt	120 ER 40

In most recessed fittings, a conventional 150 watt reflector lamp can be replaced with a 50 ER 30 or a 75 ER 30, resulting in a reduction in energy consumption of 67% or 50% respectively.

Suppliers of electrical lamps and luminaires will be able to provide further information on the foregoing products.

Fire Tube Boilers

Operation
As oil is burned, soot forms inside boiler fire tubes; the heavier the grade of oil used, the more soot is produced. Unfortunately, soot is a very effective insulator — about 8 times more effective than asbestos. Consequently, as soot builds up, less and less heat is usable for heating purposes, more and more is lost via the chimney, and more fuel is wasted. By the time the coating of soot reaches 0.159 cm (1/16") thick, about 26% of the oil is being wasted; an increase in soot to 0.318 cm (1/8") wastes over 60% of the oil.

Fire tubes should be cleaned on a regular basis to remove soot and hence keep fuel oil wastage to a minimum. Cleaning fire tubes once a month in the heating season will help to keep fuel wastage to a minimum. If it is not possible to clean tubes this frequently, they should be cleaned just prior to the start of the heating season and mid-way through the heating season.

Conservation of Fuel Oil or Natural Gas
As hot gases, produced by burning oil or natural gas, pass through boiler fire tubes, heat is given up to produce hot water or steam, depending on the type of heating system in use. In many boiler installations, hot gases are discharged via the chimney before the optimum amount of heat is extracted.

This situation can be corrected by slowing down the rate of flow of hot gases to allow more heat to be extracted and hence less fuel to be used. Devices called flame retarders (or turbulators) can be inserted into fire tubes to both slow down and cause hot gases to rotate, thus extracting more heat before discharge. Flame retarders can reduce fuel consumption by up to 10% (approximately) and cut fuel costs. They will usually pay for themselves, in fuel savings, in approximately one year.

However, the temperature of the hot gases must not be reduced below a certain level before discharge via the chimney. Otherwise, corrosive liquids can form inside boiler systems, which could cause damage. A good combustion contractor should be consulted to determine whether flame retarders should be fitted in boiler installations.

For More Information

Publications

A.S.H.R.A.E. Inc. *Energy Conservation in New Building Design. A.S.H.R.A.E. STANDARD, 90A. 1980,* 1791 Tullie Circle, NE, Atlanta, GA 30329.

Energy Security for the Eighties: A Policy for Ontario. Ontario Ministry of Energy. Available from: Ontario Government Bookstore, 880 Bay St., 5th Flr., Toronto, Ontario M7A 1N8.

Ontario Energy Review. Ontario Ministry of Energy. Available from: Ontario Government Bookstore, 880 Bay St., 5th Flr., Toronto, Ontario M7A 1N8.

The Energy Efficient Church. Edited by Douglas R. Hoffman. The Pilgrim Press, 287 Park Ave. South, New York, NY 10010. Also available from the bookrooms of Canadian religious organizations.

Films

Life Cycle Costing. Ontario Ministry of Energy. Available from City Films, 542 Gordon Baker Rd., Willowdale, Ontario M2H 3B4.

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